

AUTOMOTIVE EMC TESTING UNDER DYNAMIC DRIVING CONDITIONS

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Make ideas real

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AGENDA

- ▶ Automotive testing technical overview and challenges
- ▶ EMC testing, standards framework and future outlook
- ▶ Example of real system incl. demo video
- ▶ Summary and learnings



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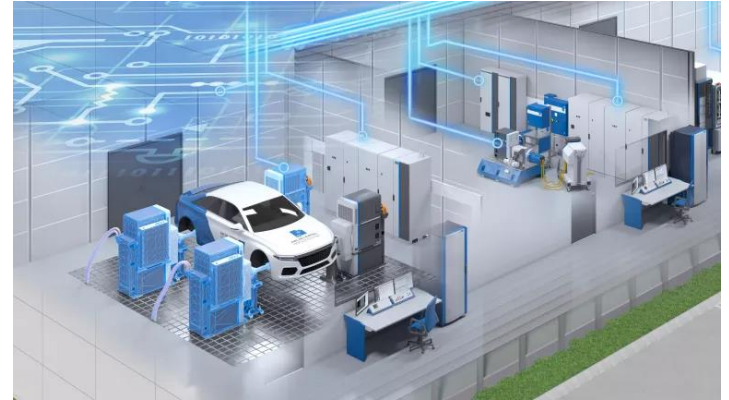


PERSONAL INTRO

Patrick Hansmann
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E-Motor Test Systems & EMC-Applications

AVL List GmbH

Patrick Hansmann studied electrical engineering at HTL Mössingerstraße in Klagenfurt Austria and graduated in Biomedical Engineering. He worked at testing and application on electrified testbeds. Since 2017 he is working for AVL List GmbH and is responsible for EMC development, testing, and troubleshooting on product and testbed system level.



E-DRIVE DEVELOPMENT AND REALIZATION OF A DYNAMIC EMC TEST SYSTEM

Transitioning to Electrified Vehicles



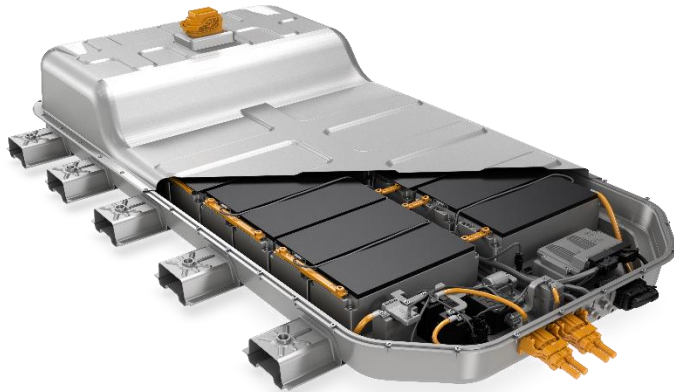
Internal Combustion Engine



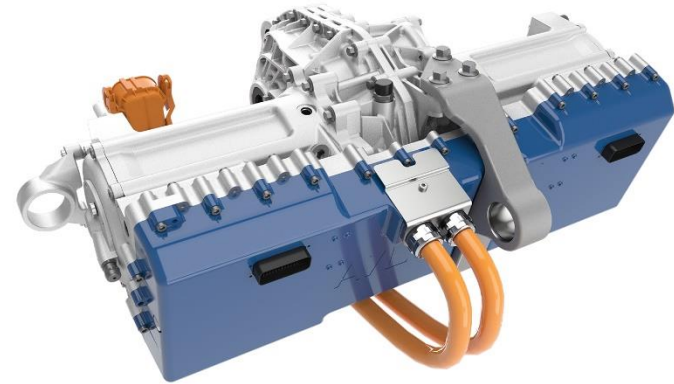
Electrified Powertrain

E-DRIVE DEVELOPMENT AND REALIZATION OF A DYNAMIC EMC TEST SYSTEM

Main Components of Battery Electric Vehicles



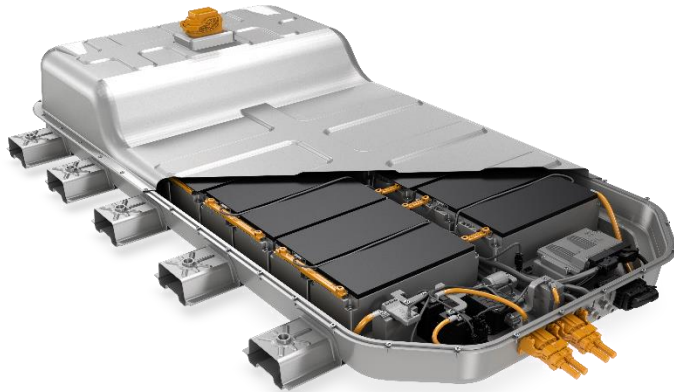
High Voltage Battery



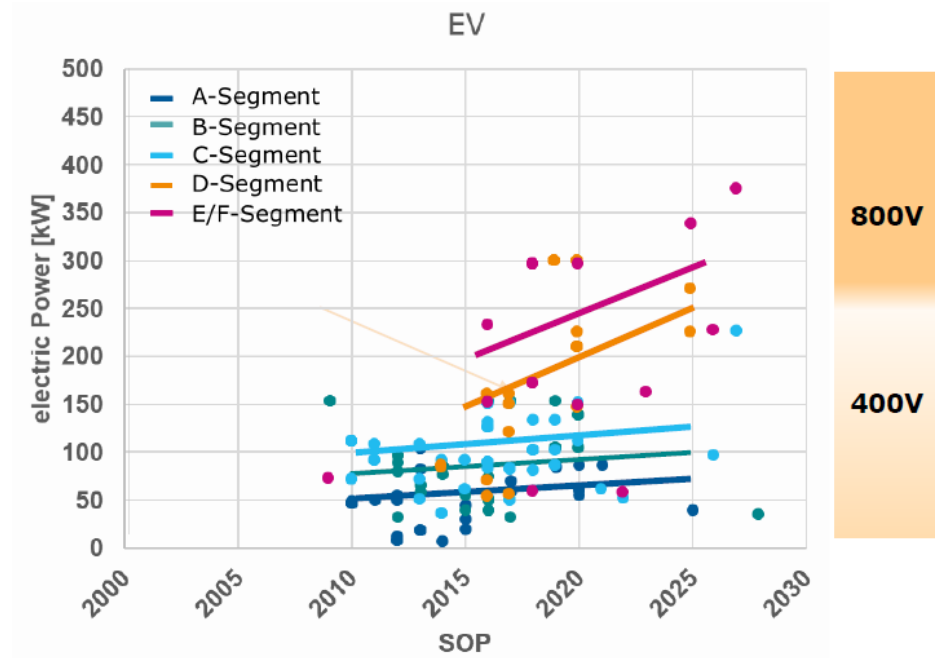
E-Drive (Inverter + E-Motor)

E-DRIVE DEVELOPMENT AND REALIZATION OF A DYNAMIC EMC TEST SYSTEM

Steady increase in High Voltage

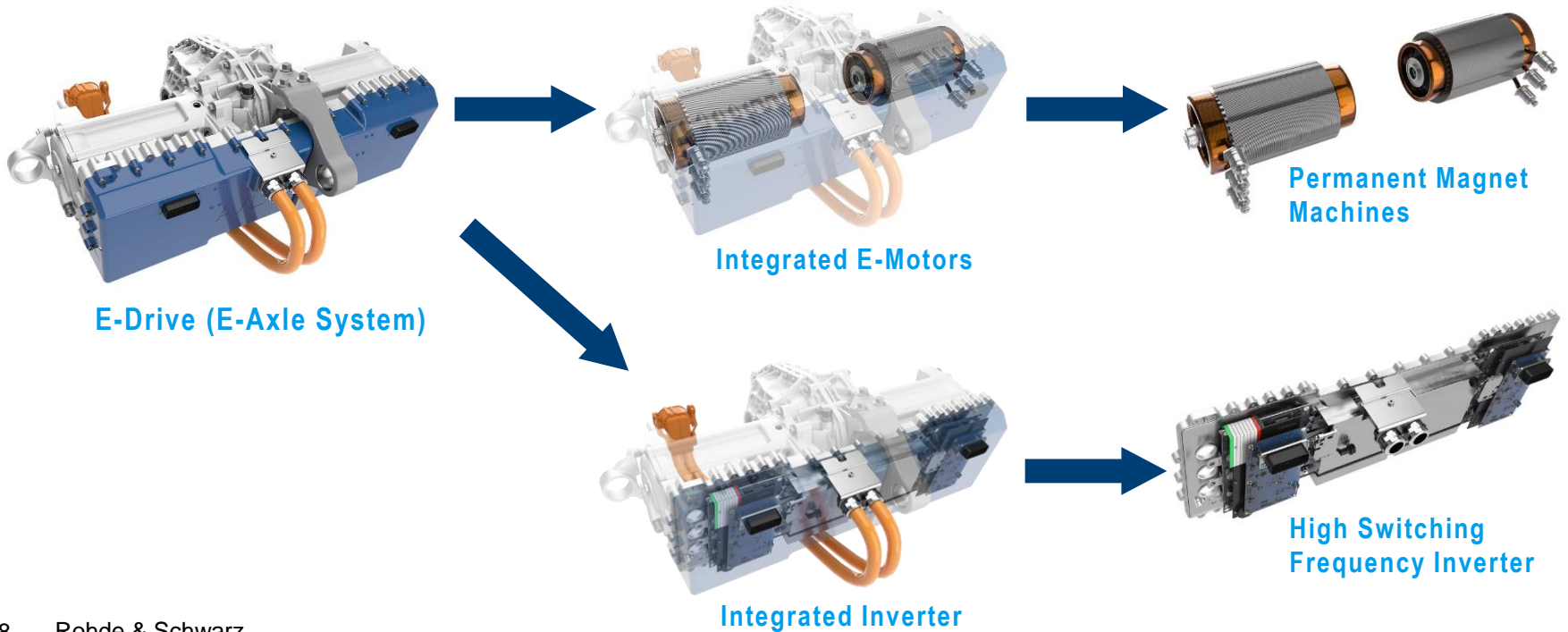


High Voltage Battery



E-DRIVE DEVELOPMENT AND REALIZATION OF A DYNAMIC EMC TEST SYSTEM

Electrified Propulsion Sub-Systems



E-DRIVE DEVELOPMENT AND REALIZATION OF A DYNAMIC EMC TEST SYSTEM

E-Motors



	PMM: > 70%
	ASM: ~ 20%
	EESM: ~ 5%
	AFM: < 5%



HIGH PERFORMANCE:

> 500 Nm
~ 20'000 rpm

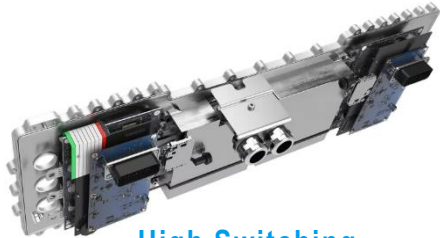


ENERGY DENSITY:

≥ 35'000 rpm

E-DRIVE DEVELOPMENT AND REALIZATION OF A DYNAMIC EMC TEST SYSTEM

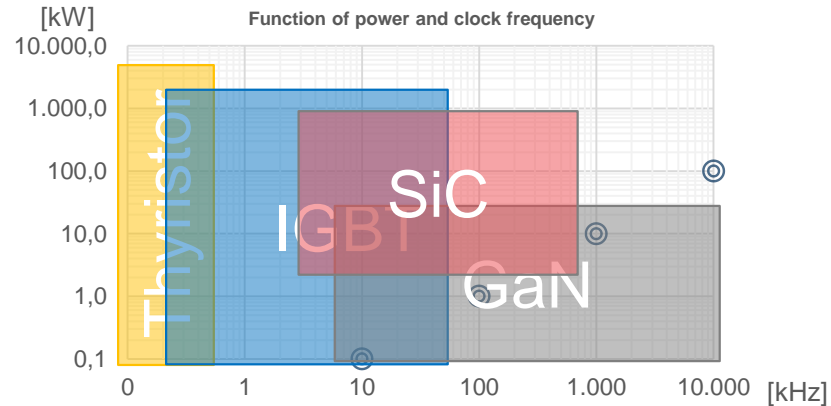
HV Inverters



High Switching Frequency Inverter

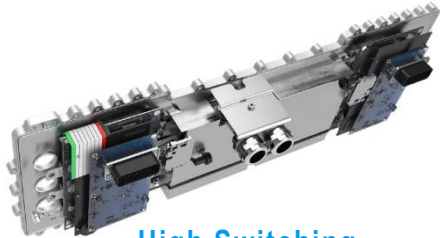
Inverter has severe influences on EMC!

- High Voltages (400 V - 800 V)
 - High Switching Frequencies
 - SiC with high Voltage gradient (dV/dt)
- } ⚡ EMC



E-DRIVE DEVELOPMENT AND REALIZATION OF A DYNAMIC EMC TEST SYSTEM

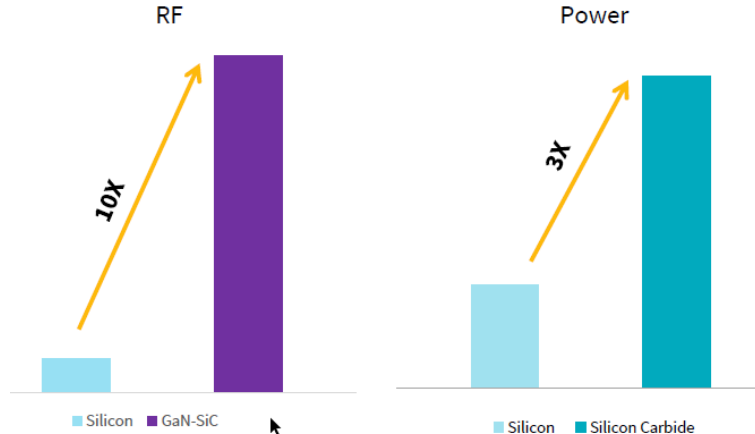
HV Inverters



High Switching Frequency Inverter

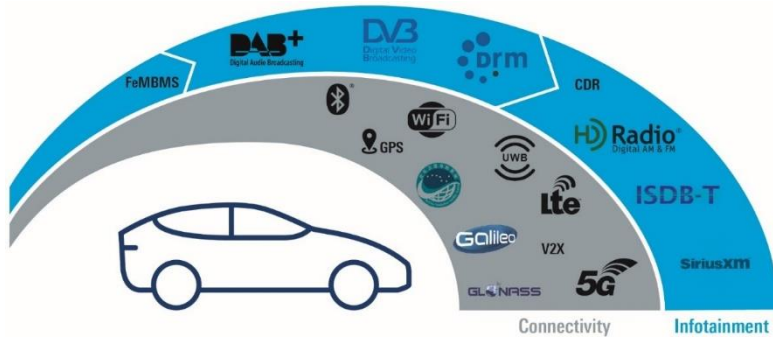
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E-DRIVE DEVELOPMENT AND REALIZATION OF A DYNAMIC EMC TEST SYSTEM

ADAS / ADAD



- Infotainment
- Connectivity
- Advanced Driver Assistant Systems
- Autonomic Driver and Assistance Data



E-DRIVE DEVELOPMENT AND REALIZATION OF A DYNAMIC EMC TEST SYSTEM

COMPONENT TESTING

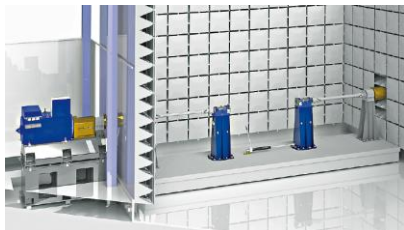
VEHICLE TESTING



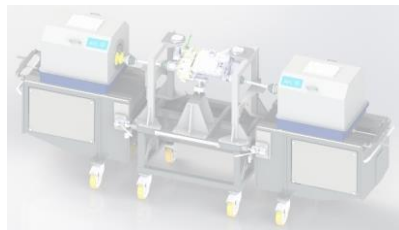
E-Motor TS™ EMC - fixed



E-Motor TS™ EMC - mobile

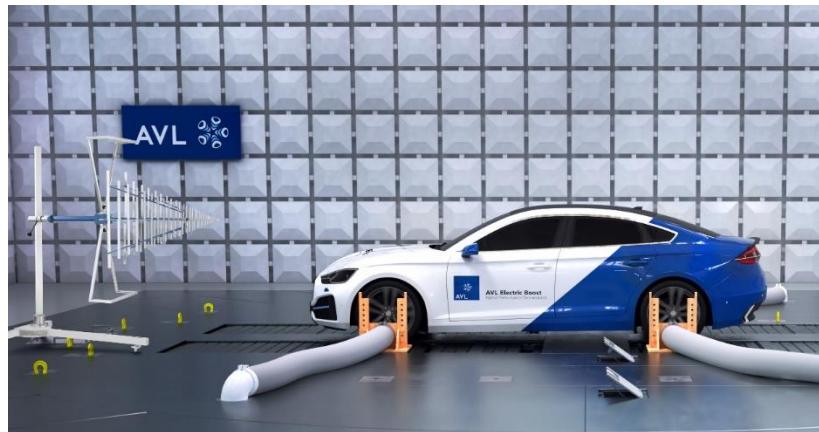


E-Axle TS™ EMC - fixed



E-Axle TS™ EMC - mobile

Full-Compliance Test Systems for Powertrain Components from Hybrid and Electric Vehicles



Full-Compliance Test System for Vehicles with Combustion Engine, Hybrid, BEV and FCEV

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AUTOMOTIVE EMC TESTING TECHNICAL OVERVIEW AND CHALLENGES

Electromagnetic emissions are typically created by

- Fast switching of currents with high gradients at high clock frequencies
- Higher currents/voltages create more emissions

This situation applies especially to electric vehicles.

To make it worse: ADAS functions in vehicles use sensitive electronics at RF frequencies in close proximity to high voltage components !

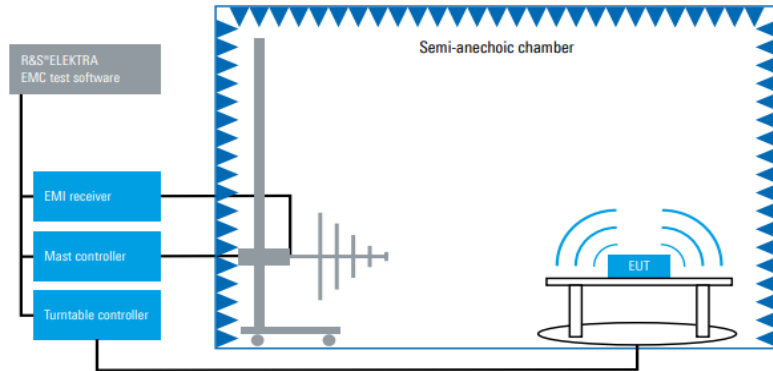


This leads to an increased need for detailed EMC testing

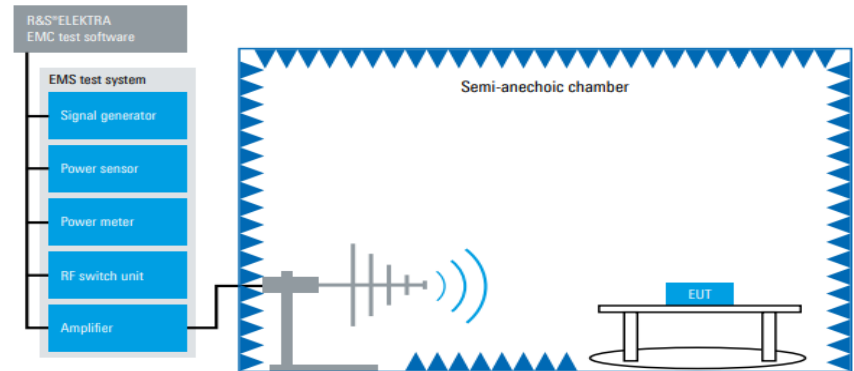
AUTOMOTIVE EMC TESTING TECHNICAL OVERVIEW AND CHALLENGES

- EMC testing is
 - EMI = Disturbance RF signals emitted from the EUT (Equipment Under Test)
 - EMS = Susceptibility/Immunity of the EUT against disturbance RF signals
- Transmission of disturbance signal is either radiated or conducted

Radiated emissions (RE) test setup



Radiated susceptibility (RS) test setup



AUTOMOTIVE EMC TESTING TECHNICAL OVERVIEW AND CHALLENGES

For all EMC measurements

- The EUT must be set into an operational mode in order to verify EMI or EMS
- The EUT should be tested at typical operational conditions to receive useful measurements results.

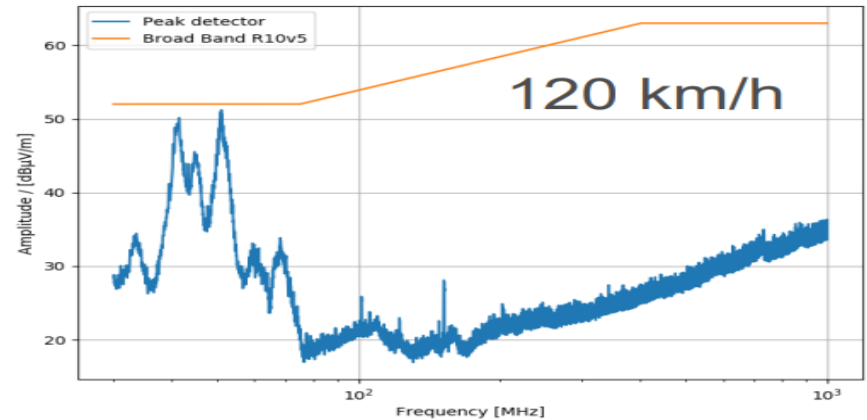
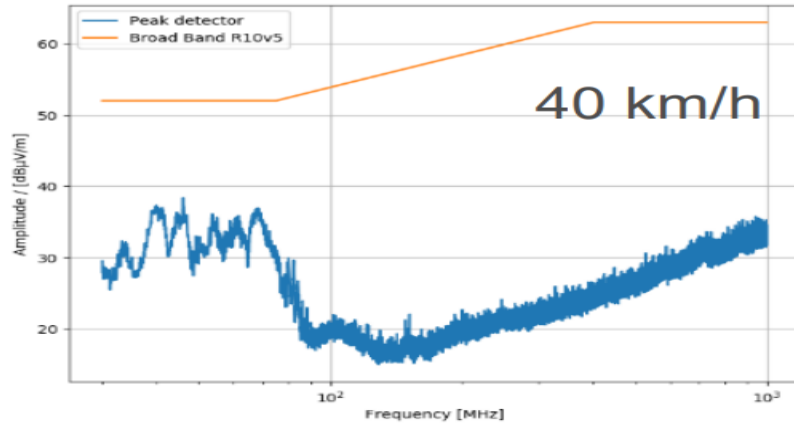
Full vehicle standards typically define precisely the operating modes so that measurements are comparable.

Example:

CISPR12 -> vehicles with electric motors shall be operated at a constant speed of 40 km/h without any torque on the wheels

AUTOMOTIVE EMC TESTING TECHNICAL OVERVIEW AND CHALLENGES

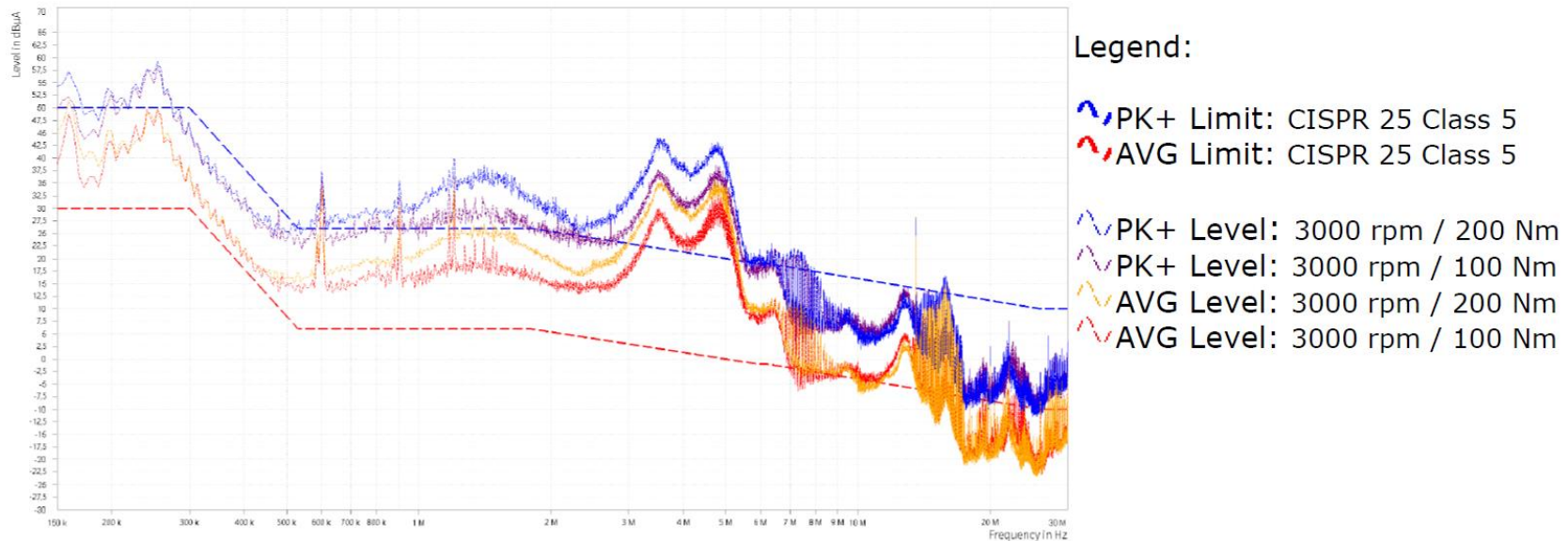
Problem: Emissions are different at different speed, and therefore a single measurement at 40km/h does not reflect the reality.



Results under dynamic speed and recuperation are even worse.

AUTOMOTIVE EMC TESTING TECHNICAL OVERVIEW AND CHALLENGES

Load change effect - current probe EMC measurement on HV line
=> Higher broadband interference emissions with torque increase



Note: the measurements have been done in a pre-compliance environment, the background level interference emissions are higher than demanded by the standards

AUTOMOTIVE EMC TESTING TECHNICAL OVERVIEW AND CHALLENGES

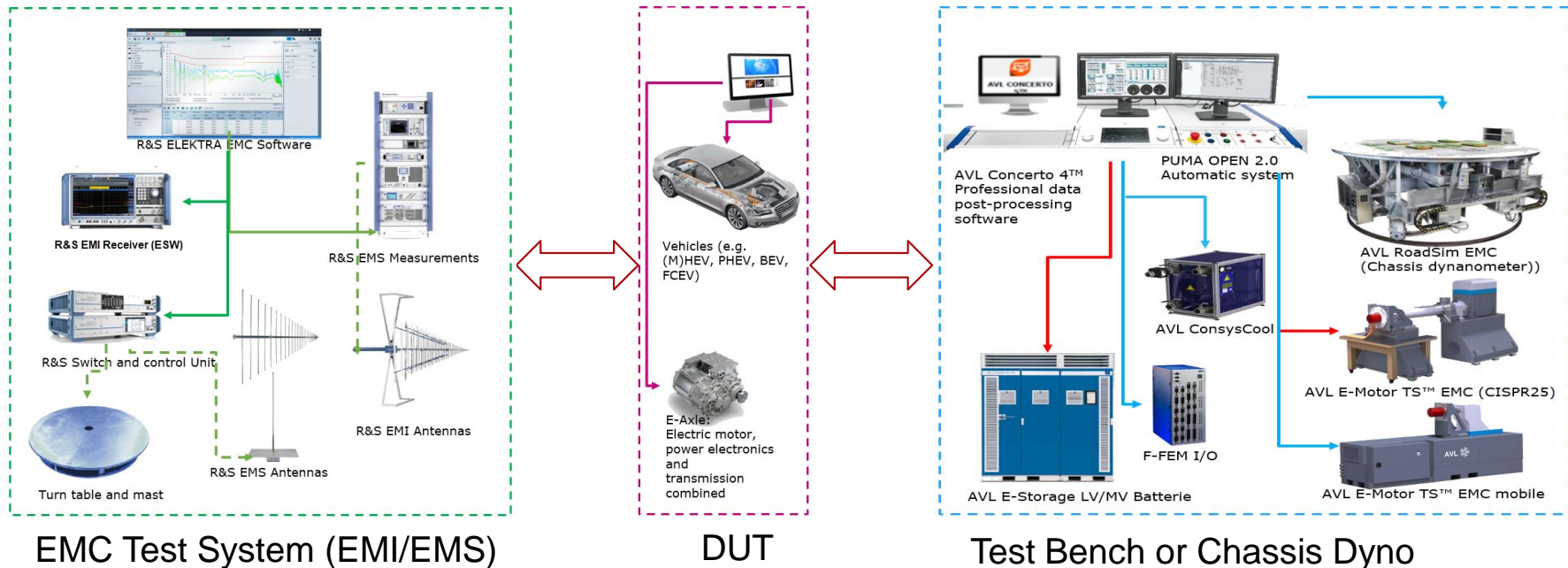
Setting the operational conditions of the EUT is becoming more complicated

- Setting several operating modes in a sequence
- Setting dynamic conditions for several parameters such as speed and torque
- Synchronizing parameters, values and measurement flow
- Operating only one software for the user
- Automatic worst case search over several parameters

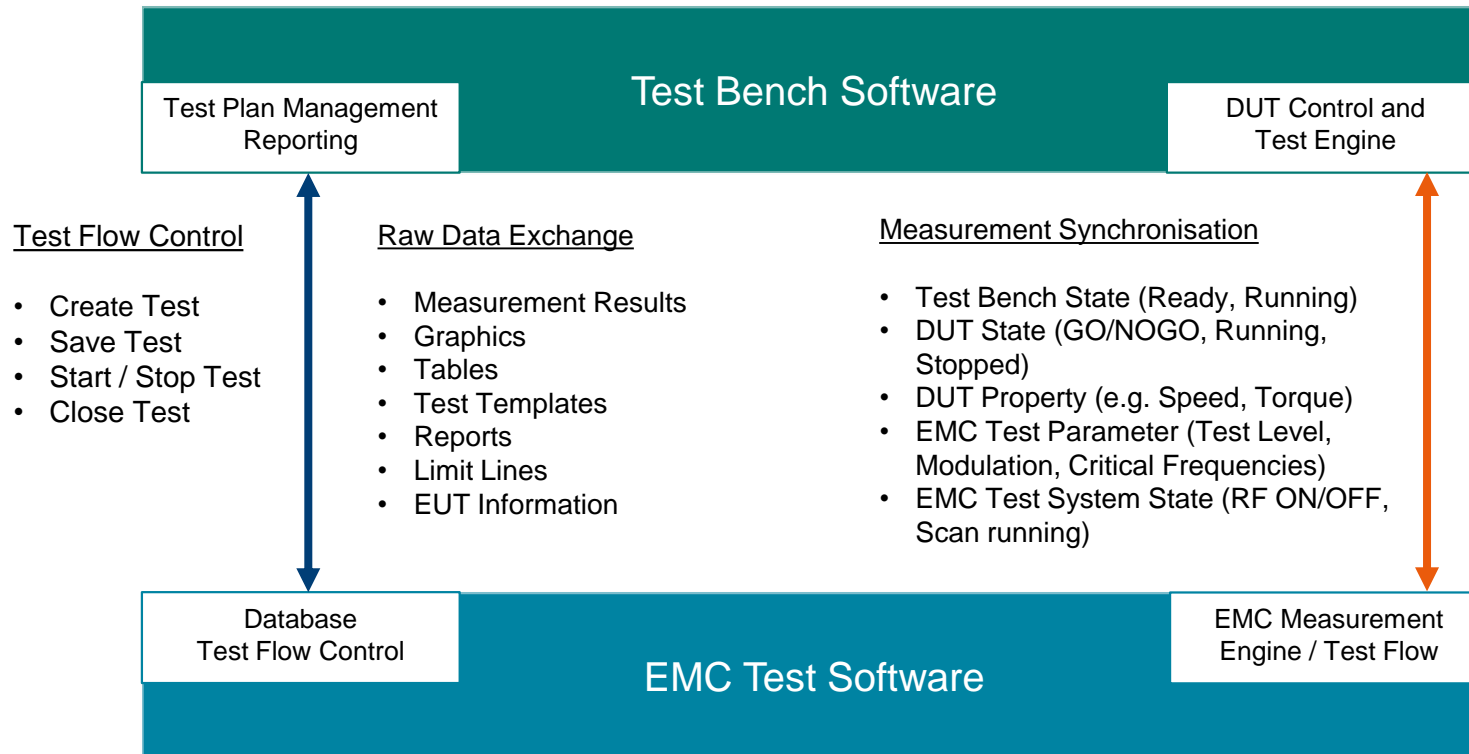


Need for advanced communication between the test bench simulating the road and the EMC automation software controlling the measurement

AUTOMOTIVE EMC TESTING TECHNICAL OVERVIEW AND CHALLENGES



TEST SYSTEM SYNCHRONIZATION



EMC STANDARDS FRAMEWORK AND FUTURE OUTLOOK

EMC measurements typically follow international standards for traceable, comparable and reproducible results.

ISO 11451 series – Full vehicle testing, EMS

ISO 11452 series – subassembly testing, EMS

CISPR series – off/onboard receivers EMI, wireless power transfer

GB/T series - Chinese standards

Standards that reference the above but add details or apply modifications

- ▶ UN ECE R10 – homologation/approval of vehicles with regard to EMC
 - This is the minimum requirement for all OEMs, a MUST HAVE
- ▶ OEM specific regulations for component suppliers
 - This typically goes beyond the UN ECE R10 depending on the QA requirements or market positioning of the vehicle.

EMC STANDARDS FRAMEWORK AND FUTURE OUTLOOK

EU Commission and others have identified the gap between current standardization and emissions under dynamic (or realistic) driving conditions.

International standardization is a quite complex process which takes time:

- There have to be studies to generate a procedure/setup that fulfills the requirements
- A standard shall be stable and valid for a reasonable period of time
- Procedures, setups and limits must be technically and commercially feasible
- A lot of stakeholders are involved
- A standard must work for all specified products



Testing beyond the standard requirements is good practice to increase quality
See: OEM standards, regional standards

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DEMO VIDEO

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SUMMARY AND LEARNINGS

- New technologies and new components in electric vehicles create new EMC challenges
- EMC standards do not yet reflect the issues that come up with electric vehicles and ADAS functions
- Testing under various and especially dynamic driving conditions is seen essential
- R&S and AVL have created a comprehensive combined solution that provides full test coverage in one integrated system, ideal for dynamic electric drivetrain EMC testing
- Be ahead of the market, prepare for possible new EMC compliance requirements with testing beyond the standard



Automotive

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